EE 323
Electronics Instrumentations
Instructor: A. Dinh

MIDTERM EXAMINATION

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(Use the other sides of the papers if needed.)

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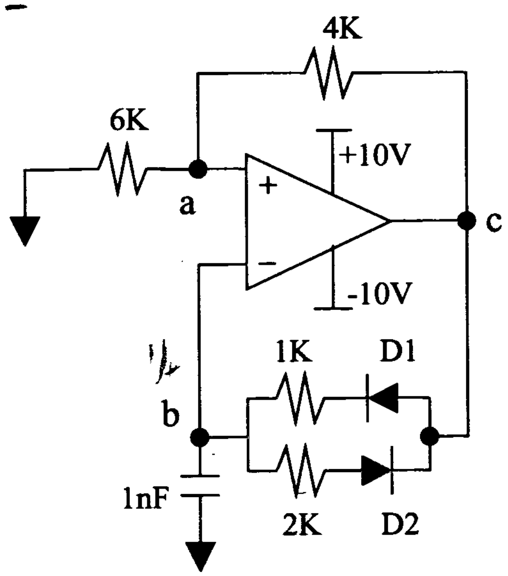
Questions 1: (20marks)

For the circuit below, make appropriate assumptions, sketch the waveforms at the op-amp terminals (i.e., node a, b, c).



Assume Ideal op-amp

$a = V_+ = \frac{R_1}{R_1+R_2} C$

12

Assume C initially uncharged

Charging

$V_b = 12 - (12) - (-12 + V_D) e^{-\frac{t}{RC}}$ use $R = 2k\Omega$ current will flow from b to c.

$= 12 - (24 - V_D) e^{-\frac{t_1}{(2k)(1\times10^{-9})}}$ when $t = t_1$ $V_b = 12V - V_D$

$12V - V_d = 12 - (24 - V_D) e^{\frac{-t_1}{(2k)(1\times10^{-9})}}$

$\frac{V_d}{24 - V_d} = e^{\frac{-t_1}{(2k)(1\times10^{-9})}}$

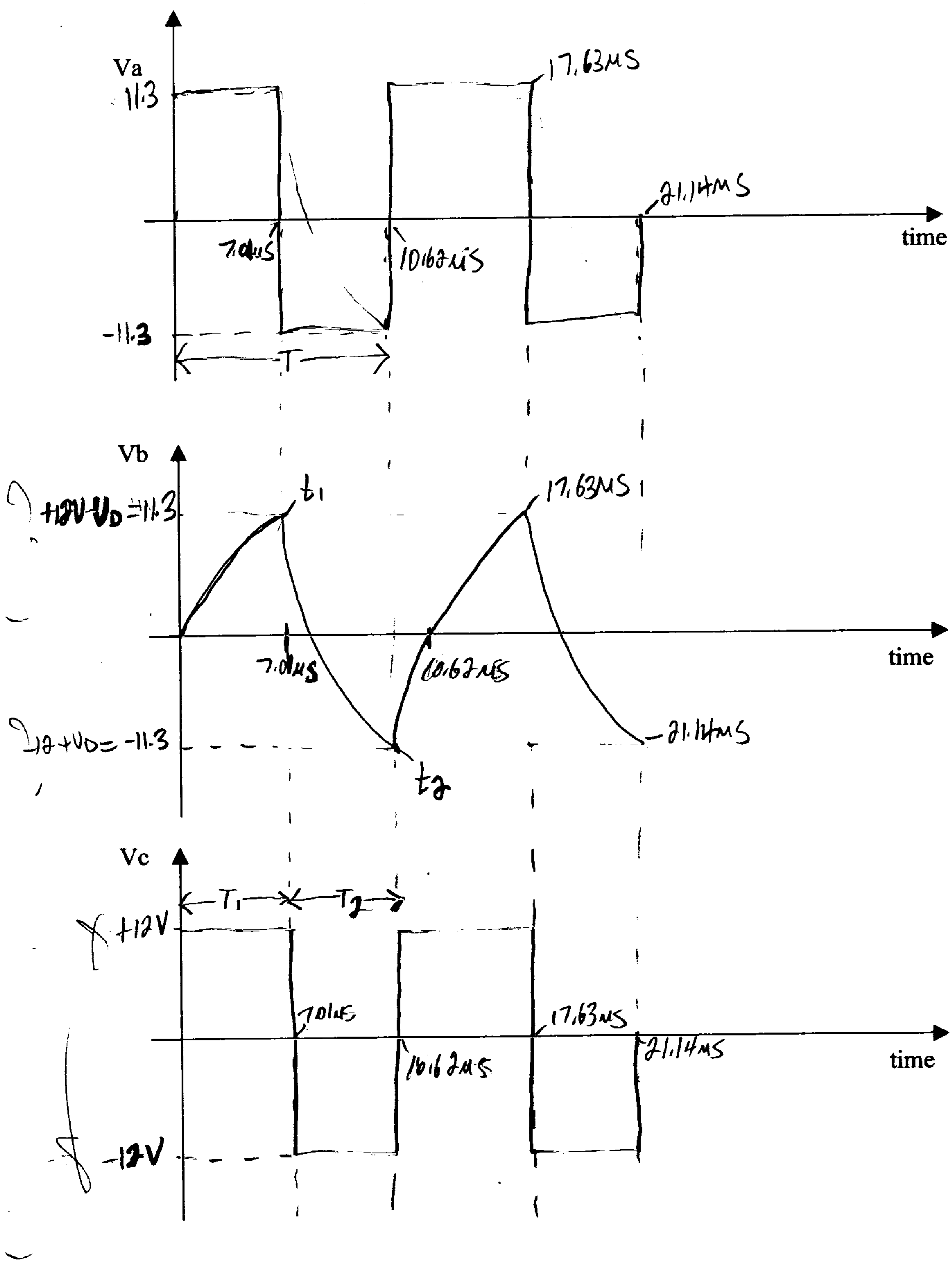
$\frac{t_1}{2k(1\times10^{-9})} = \ln\left(\frac{24 - V_d}{V_d}\right)$

$t_1 = 7.01\mu S$

In our case $t_1 \neq t_2$ b/c of different R btw b & C.

$t_2 = (1k)(1\times10^{-9}) \ln\left(\frac{24 - V_d}{V_d}\right) = 3.51\mu S$

$T = 7.01\mu s + 3.51\mu s = 10.62\mu S$


Va
11.3
17.63MS
21.14MS
time
7.01MS
10.62MS
-11.3
T
Vb
t1
+12V-VD=11.3
17.63MS
time
7.01MS
10.62MS
-12+VD=-11.3
-21.14MS
t2
Vc
T1
T2
+12V
7.01MS
17.63MS
21.14MS
10.62MS
time
-12V

Question 2: (30marks)

Part 1:

An op-amp has the following open-loop transfer function:

$$A(j\omega) = \frac{v_{out}}{v_{in}} = \frac{10^5}{(1+j\frac{\omega}{\omega_1})(1+j\frac{\omega}{\omega_2})(1+j\frac{\omega}{\omega_3})}$$

where $\omega_1 = 100$rad/s, $\omega_2 = 10^3$rad/s, and $\omega_3 = 10^5$rad/s.

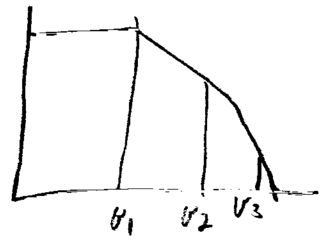
i. If the op-amp is connected in a unity positive feedback configuration. What is the output frequency of the op-amp?

$A(jW)=1$ in unity feedback

$\therefore 10^5 = \left|(1+j\frac{W}{W_1})(1+j\frac{W}{W_2})(1+j\frac{W}{W_3})\right|$

$W > W_3$ when gain $=1$

$\boxed{W \approx 87000 \text{ rad/s}}$



-100 000

ii. If the op-amp is to be connected in a negative feedback configuration. What is the maximum feedback coefficient that can be tolerated before instability results? What is the minimum closed-loop gain of this op-amp without oscillation?

Find W

$-180° = -\tan^{-1}\left(\frac{W}{100 \text{rad/s}}\right) - \tan^{-1}\left(\frac{W}{10^3 \text{rad/s}}\right) - \tan^{-1}\left(\frac{W}{10^5 \text{rad/s}}\right)$

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$W_{180} = 65928.55$ rad/s

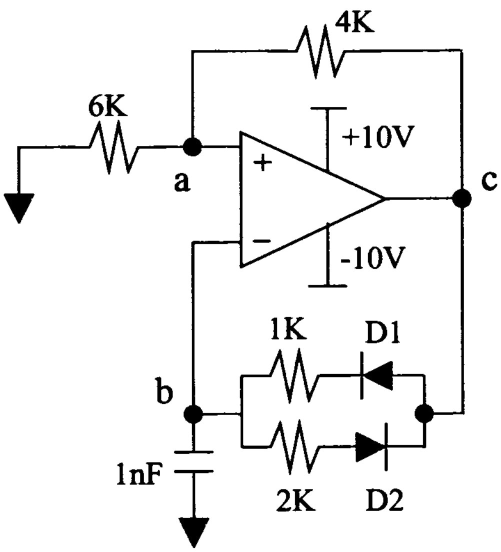
$A_{180} = \left|\frac{10^5}{\left(1+j\left(\frac{65929}{100}\right)\right)\left(1+j\left(\frac{65929}{1000}\right)\right)\left(1+j\left(\frac{65929}{100000}\right)\right)}\right| = 1.92 \approx 2$

$\beta \leq \frac{1}{2} = \boxed{0.5}$

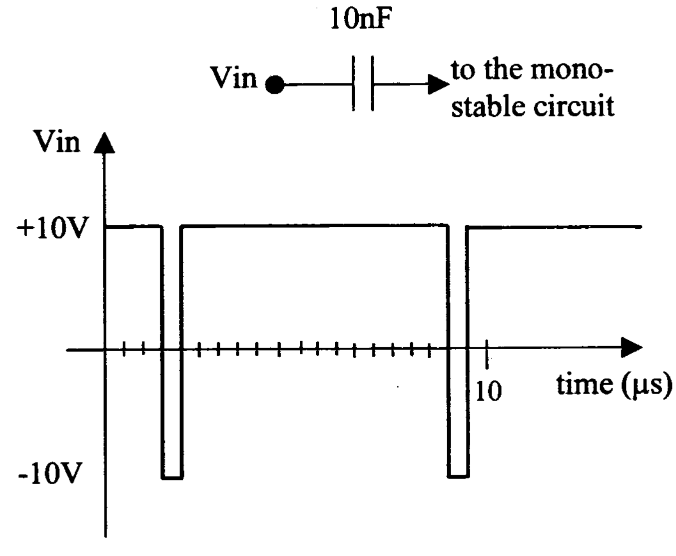
$\boxed{A_{CL} \geq 2}$

Part 2:

The circuit in Question 1 is shown below (a); without adding or deleting any component, re-arrange the circuit to make it function as a mono-stable circuit. Connect your circuit to the input Vin given in (b), sketch the waveforms at the op-amp terminals a, b, c of your modified circuit.

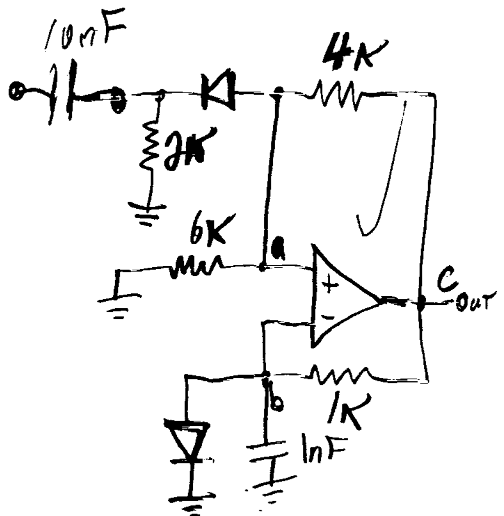


(a)



Input for the mono-stable circuit

(b)



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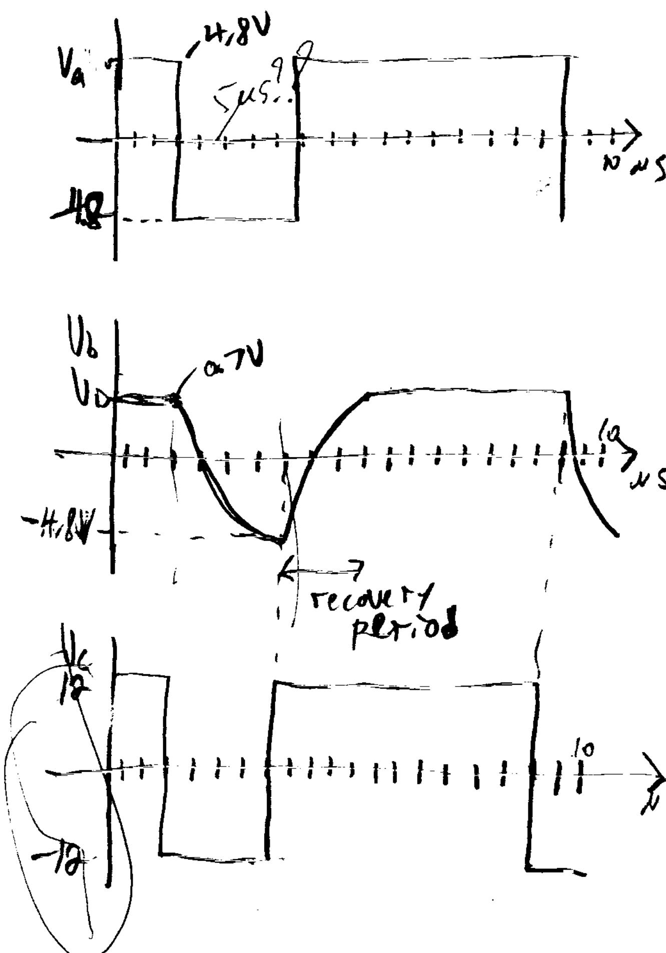
$\beta L_+ = \frac{4K}{10K}(12) = \pm 4.8V$



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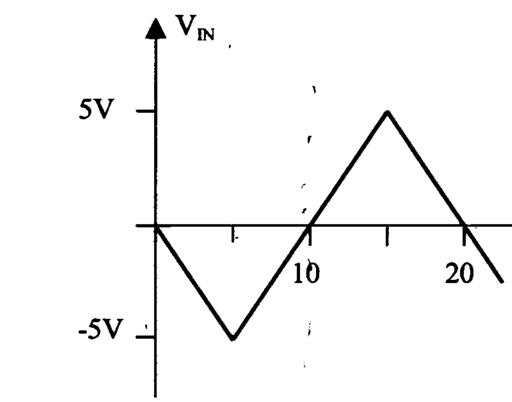
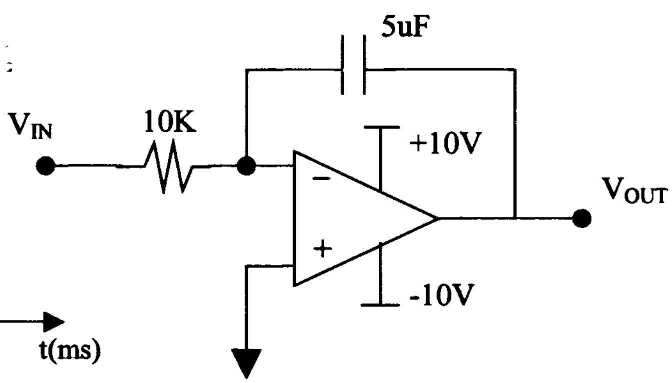
Question 3: (10marks)

A 5V peak triangular voltage with a period of 20ms, depicted on the axis shown below, is applied to an ideal op-amp integrator. Sketch V_{OUT} as a function of time. The capacitor has zero initial charge.





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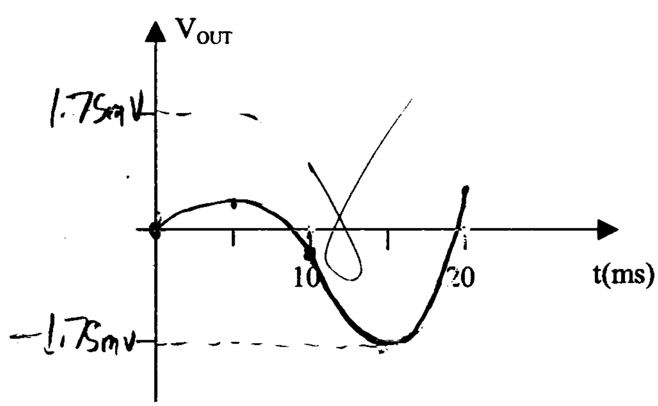
$V_o = -\frac{1}{RC}\int V_i dt$



b/w 0-5

$V_o = -\frac{1}{RC}\int_{0ms}^{5ms} -t\,dt = +\frac{1}{RC}\frac{1}{2}t^2\Big|_0^5 dt$

$= \frac{1}{RC}\frac{1}{2}(5ms)^2 \; \frac{1}{(10k)(5\times10^{-6})2}(5\times10^{-3})^2 = 0.25\,mV$

at $t = 5ms$ $V_{OUT} = 0.25mV$

at $t = 10ms$ $V_{OUT} = -0.5mV$

b/w 5-15ms

$V_o = -\frac{1}{RC}\int_{5\times10^{-3}}^{15\times10^{-3}} t + V_{out} = \frac{-1}{(10k)(5\times10^{-6})}\frac{1}{2}t^2\Big|_{5ms}^{15ms} + 0.25mV = -1.75mV$

at $t = 15ms$ $V_{out} =$

b/w 15ms-20ms

$V_o = -\frac{1}{RC}\int_{15ms}^{20ms} -t + V_o = +\frac{1}{(10k)(5\times10^{-6})}\frac{1}{2}t^2\Big|_{15ms}^{20ms} - 1.75mV = 0$

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